be seen, for at any rate a plastoid is not present. A somewhat casual examination was also made of many organs of movement, but in them no plastoid was observed. In *Drosera rotundifolia* and other species plastoids occur which resemble those of *Drosera dichotoma*. Strong single induction shocks or tetanising currents cause the plastoid to assume the spherical condition, or very frequently to break up into a string of small spheres. A sudden blow on the cover slip also causes the assumption of the spherical form. Moderately strong tetanising shocks cause swelling of the protoplasm, and increase of rapidity of movement and granularity. Very strong shocks may cause the contraction of the primordial utricle from the cell-wall at certain small areas, but immediate death always ensues, since the stimulus required is abnormally great. The normal effect of a regulated stimulus is to induce a swelling of the protoplasm and a loss of turgidity, and in consequence of the unequal reaction of the various cells to such a stimulus, movement of the tentacle also occurs.

[Note.—I have decided to name the body which I have provisionally spoken of as the plastoid "the rabdoid" (Gk. *rabdos*, a stick or wand). The change in form of the rabdoid appears to be a consequence of the molecular changes in the protoplasm. Differences of turgidity are among the results of these changes.—Nov. 28, 1885.]

VI. "On Variations in the Amount and Distribution of Fat in the Liver-Cells of the Frog." By J. N. Langley, M.A., F.R.S., Lecturer on Histology in the University of Cambridge. Received September 23, 1885.

I have in a previous paper* mentioned some of the changes which occur in certain circumstances in the number and arrangement of the fat-globules in the liver-cells of the frog. From observations made since that time at different seasons of the year, I have been able to ascertain certain points undetermined in the previous account.

Variations in the Amount and Distribution of Fat with the time of Year.—The fat in the liver-cells is at its maximum amount in February and March. In January it is, as a rule, somewhat less. In April it rapidly decreases; from May until December it is present in comparatively small though varying amount. It is usually present in minimum amount in September and October.

Generally speaking, the fat-globules form an inner zone in frogs which have hungered more than a week. In January, February, and March, however, the fat-globules are commonly more numerous in the outer part of the cells, often forming a distinct outer zone.

* "Proc. Roy. Soc.," vol. 34, p. 20.

Sometimes the globules stretch throughout the cells. In December, the fat-globules may be more numerous in the outer part of the cells, but more commonly they are absent from the outer cell-region and form an inner zone. At other times of the year also, the fat-globules may be present in the outer portion of the cells, but this is comparatively rare.

From April to November, including those months, the globules may be very few and small. In December this is, so far as I have observed, very rare. In January, February, and March, I have always found fat-globules to be present in considerable number.

Effect of Temperature.—In December, when the fat in the liver is increasing in amount, cold increases the amount of fat stored up, and warmth decreases it.

The increase of fat, consequent on a decrease of temperature, occurs chiefly in the outer part of the cells. The fat-globules which are formed are fairly large.

The decrease of fat, consequent on increase of temperature, occurs chiefly or wholly at the outer part of the cells; as a rule, the number of globules in the inner part of the cells is increased. The decrease in the amount of fat, whilst due in part to a decrease in the number of fat-globules, is due to a still greater degree to their decrease in size.

Although warmth lessens the amount of fat in the liver in winter-frogs, it does not cause the fat to disappear entirely. The effect varies; in some frogs which have been kept seven to ten days at 22° C., the liver may still have considerably more fat than is ordinarily present in the liver in summer-frogs.

In summer-frogs, in which the fat-globules form an inner zone, and are nearly or entirely absent from the outer cell-region, neither warmth nor cold affects to any great degree the number or position of the fat-globules. They usually diminish somewhat in number and size with increase of temperature, but this is not necessarily the case. Variations of temperature have then much greater effect on the amount of fat in the liver in winter than in summer, *i.e.*, whilst in winter the ratio of fat formed to fat metabolised is greater in the cold than in the warm, in summer this is not necessarily the case.

Although summer-frogs have sometimes very little fat in the liver, it is doubtful whether the smallness of the amount is due either to the warmth of summer or to hunger, for we have seen that warmth does not necessarily cause a disappearance of fat from the liver; and frogs after long hunger have not infrequently a fair amount of liver-fat left. Hence the ratio of fat formed to fat metabolised, depends in part upon certain unknown conditions of the body, independent of temperature or of food.

Effect of Digestion.—When frogs are fed, *e.g.*, with worms, the fat in the liver at first decreases, after some hours it begins to increase and becomes greater than at the beginning of digestion; towards the end of digestion it decreases again in amount, so that in one or two days the amount is normal. Whilst the fat is decreasing in amount, the globules usually decrease in size; whilst the fat is increasing in amount, the globules usually increase in size, and are found in the outer region of the cells. Later, as the fat returns to normal, the globules form more and more an inner zone.

The extent of the changes just mentioned as occurring during digestion, as well as the period of digestion at which they occur, varies very considerably at different times of the year, and in different frogs. Winter-frogs which have before digestion much fat in the liver, show a decrease and subsequent increase of fat during digestion, but the increase is commonly not more than sufficient to bring the fat up to the amount present before food was given.

In some cases in summer-frogs, especially in September and October, the effect of feeding is very slight. There are also certain differences in the distribution of the fat-globules in different frogs, in the several stages of digestion. Usually when there are many fat-globules present in the outer part of the cells before digestion, they increase in number during the first stage of digestion in the *inner* part of the cells; but this is not always the case, whilst disappearing from all parts of the cell, they may disappear much more rapidly from the inner than from the outer cell-region.

Further, when fat-globules are present in the inner zone only, it may happen that, although they increase somewhat in number in the cells in the later stages of digestion, they do not accumulate in the outer cell-region, but are sparsely scattered in the outer cell-region, and are more numerous in the inner cell-region.

Probably these differences are to be accounted for in the following way.

We have seen that when fat is present in considerable amount, it is present almost without exception in greater quantity in the outer than in the inner part of the cells, and that in most cases, as it is increasing in amount, whether from decrease of temperature, or from digestion, it increases in the outer part of the cells, frequently being found close to the basement membrane. Hence we may conclude, that fat is formed more rapidly in the outer than in the inner part of the liver-cells.

We have seen that when winter frogs are kept in the warm, it is in the outer portion of the cells that the fat chiefly disappears, and that in summer-frogs, fat is rarely found except in the inner cell-region. Hence probably the metabolism as well as the formation of fat is more rapid in the outer than in the inner cell-region.

Further we have seen that in winter-frogs kept in the warm, and in fed winter-frogs, there is commonly an increase in the number of fat-globules in the inner zone although the total amount of fat is much diminished. Hence probably there is in certain circumstances a transference of fat-globules from the outer to the inner part of the cells. The amount of fat present in the liver of course depends upon the relative rates of formation and metabolism of fat, and as this varies in different circumstances, so probably the rate of transference of fat from the outer to the inner cell-region varies in different circumstances. To this the differences spoken of above are probably due. In summer frogs for example, whilst in the later stages of digestion fat is formed more rapidly in the outer cell-region, an accumulation of fat in this region may not take place, partly on account of the more rapid metabolism of the fat formed, and partly on account of its more rapid transference to the inner cell-region.

Some of the fat-globules in the inner zone are no doubt passed out of the cell with the bile secreted, for some small fat-globules are always present in the bile.

One other conclusion we may draw with regard to the fat-globules: since they diminish in size under the influence of warmth, and in the first stage of digestion, it is probable that each separate fat-globule is slowly metabolised in the same way that mesostate granules in secretory glands are metabolised. The granules of the salivary glands, of the gastric glands, of the pancreas, are not dissolved as a whole during secretion, they are dissolved steadily and gradually.

The Effect of Peptone and of Dextrin.—From June to August, peptone or dextrin, when injected into the dorsal lymph-sac of a frog, produces changes like those produced by feeding; *i.e.*, there is at first a decrease in the amount of fat in the liver, then an increase chiefly in the outer part of the cells, and this is succeeded by a decrease to the normal state, during which the fat-globules become shifted from the outer to the inner cell-region. The increase of fat is usually greater with dextrin than with peptone. As a rule the increase in the amount of fat takes place three to four hours after peptone has been injected; in twenty to thirty hours after the injection, the fat-globules are present, as at starting, in the inner cell-region only. The times at which the various changes take place vary, however, in different frogs. If frogs are kept in the warm and peptone is injected, the effect on the fat in the liver is much less than when the frogs are at the ordinary temperatures. In September the effect of peptone appears to be less than from June to August. In the winter months I have not made a sufficient number of experiments to be certain what changes peptone and dextrin then produce.

Sewall has pointed out that peptone injected into the dorsal sac of a frog, causes, in one to two hours, the stomach to be distended with

fluid of a neutral or slightly acid reaction. This distension of the stomach occurs in most but not in all cases. The fluid is, I find, usually alkaline, sometimes both the mucous fluid in the stomach and the stomach-wall itself are strongly alkaline. The fluid contains a small amount of pepsin. Dextrin produces a similar but less distension of the stomach, the mucous fluid in this case is usually acid. I may mention that digestion in the frog is delayed very greatly by peptone, and slightly by dextrin. The stimulus set up by the fluid in the stomach may have something to do with the changes in the liver which follow injection of peptone or of dextrin. But since the changes in the liver occur in the cases in which the injection causes little or no formation of fluid in the stomach, I attribute them in the main to the direct action of the substance injected. This I am the more inclined to do since I find that both peptone and dextrin cause in a few hours an accumulation of glycogen* in the liver in summer-frogs.

November 26, 1885.

THE PRESIDENT in the Chair.

In pursuance of the Statutes, notice was given from the Chair of the ensuing Anniversary Meeting, and the list of Officers and Council nominated for election, was read as follows:—

President.—Professor George Gabriel Stokes, M.A., D.C.L., LL.D.

Treasurer.—John Evans, D.C.L., LL.D.

Secretaries.— { Professor Michael Foster, M.A., M.D.
The Lord Rayleigh, M.A., D.C.L.

Foreign Secretary.—Professor Alexander William Williamson, LL.D.

Other Members of the Council.—Professor Robert B. Clifton, M.A., Professor James Dewar, M.A.; Professor William Henry Flower, LL.D.; Archibald Geikie, LL.D.; Sir Joseph D. Hooker, K.C.S.I.; Professor Thomas Henry Huxley, D.C.L., LL.D.; Admiral Sir A. Cooper Key, G.C.B.; J. Norman Lockyer, F.R.A.S.; Professor Henry N. Moseley, M.A.; Professor Bartholomew Price, M.A.; Reverend Professor Pritchard, D.D., F.R.A.S.; William James Russell, Ph.D.; Professor J. S. Burdon Sanderson, LL.D.; Professor

* Seegen has shown that peptone increases the amount of sugar in the liver.